FIGURE 1

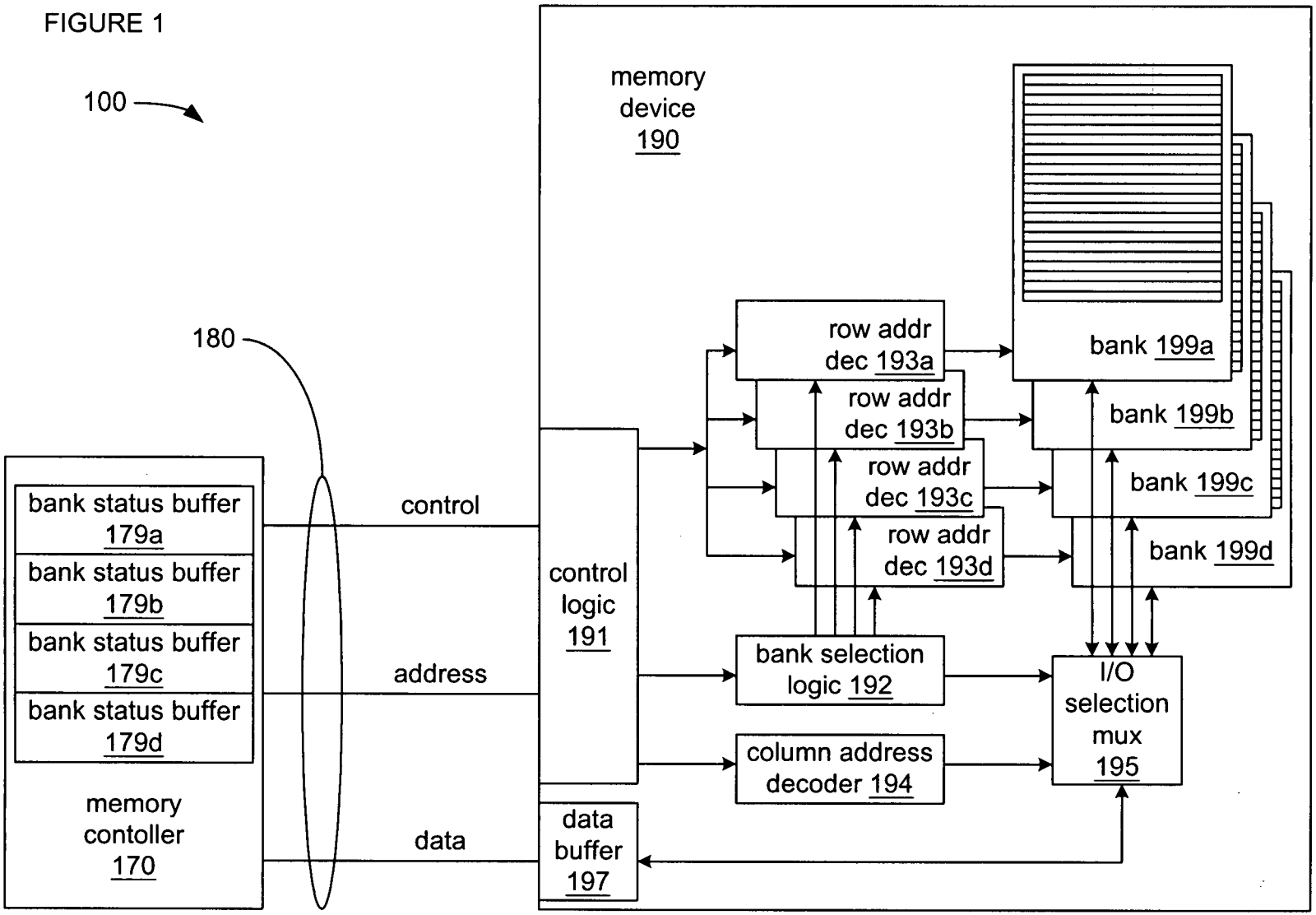

100
memory device 190
180
bank status buffer 179a
bank status buffer 179b
bank status buffer 179c
bank status buffer 179d
memory contoller 170
control
address
data
control logic 191
data buffer 197
row addr dec 193a
row addr dec 193b
row addr dec 193c
row addr dec 193d
bank 199a
bank 199b
bank 199c
bank 199d
bank selection logic 192
column address decoder 194
I/O selection mux 195

FIGURE 2a

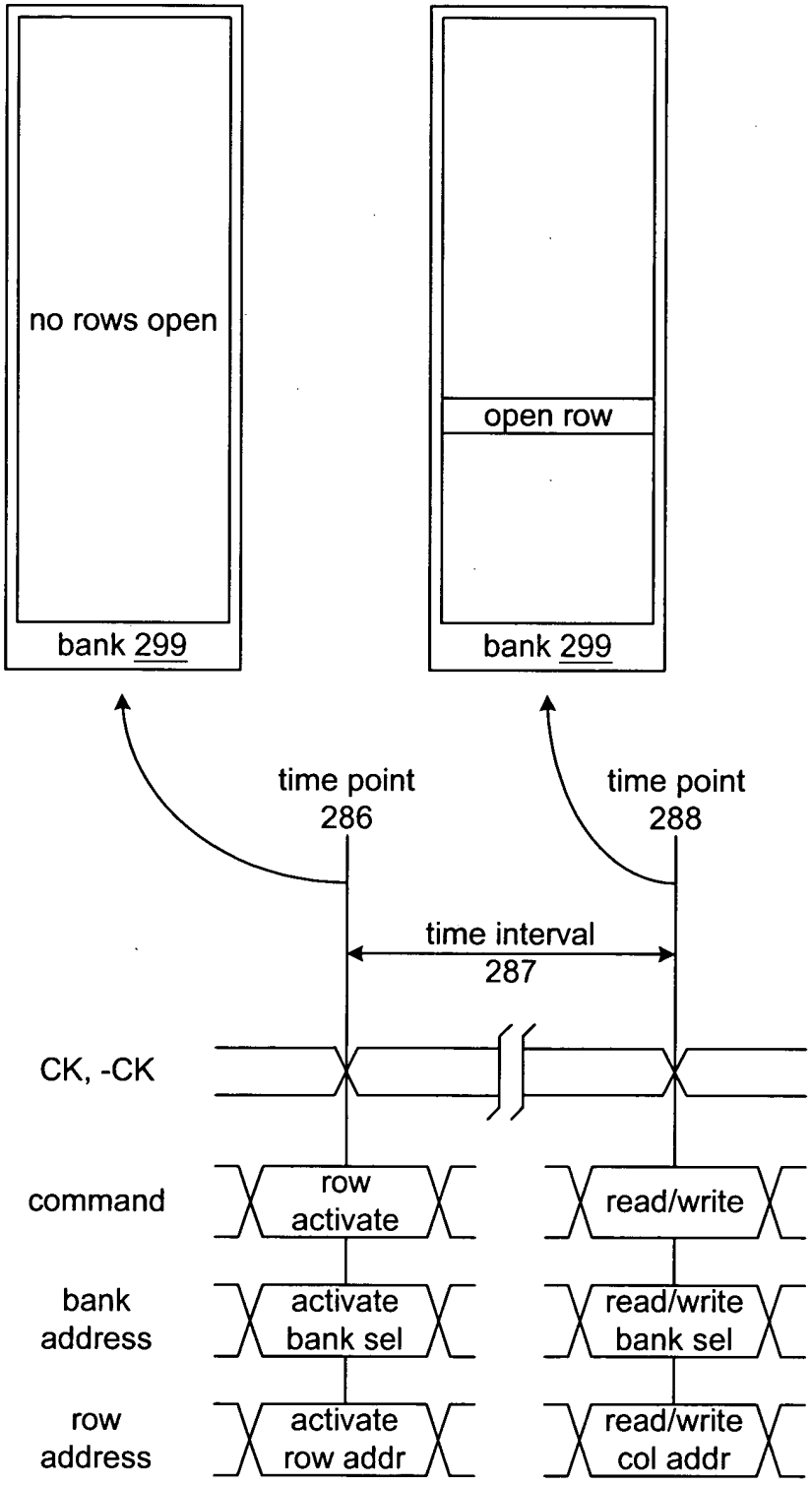

no rows open
bank 299
open row
bank 299
time point
286
time point
288
time interval
287
CK, -CK
command
row
activate
read/write
bank
address
activate
bank sel
read/write
bank sel
row
address
activate
row addr
read/write
col addr

FIGURE 2b

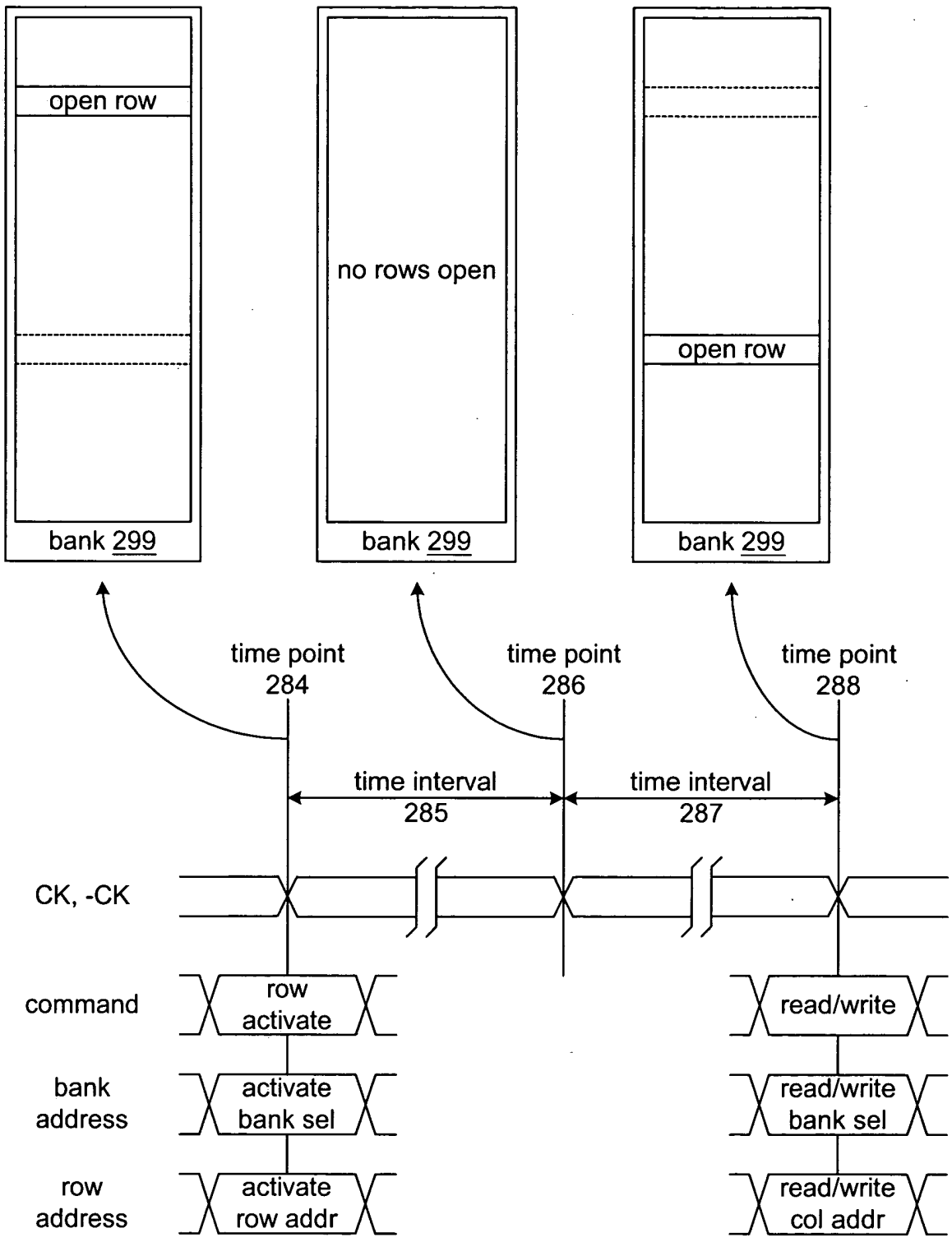
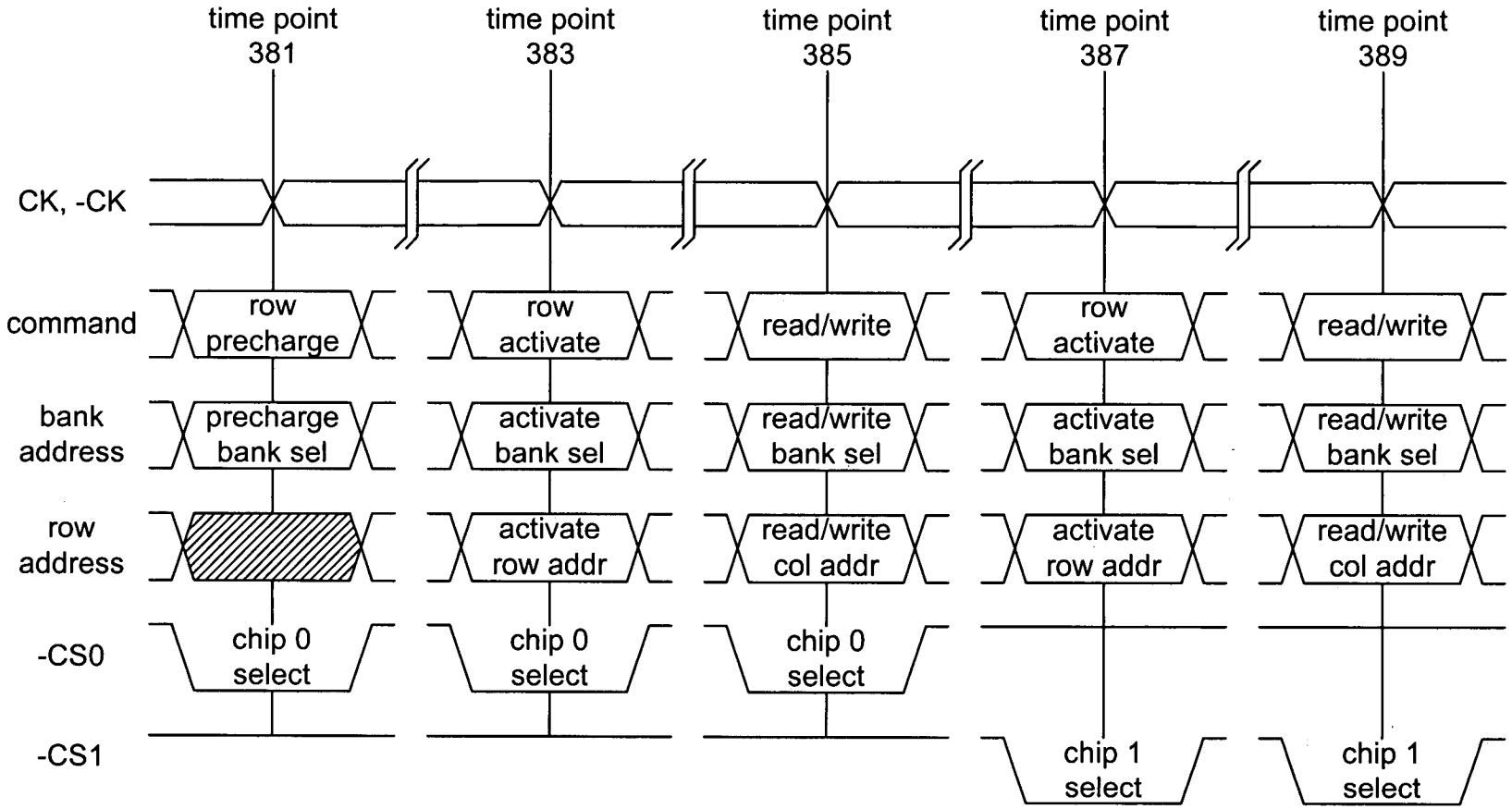

open row
bank 299
no rows open
bank 299
open row
bank 299
time point 284
time point 286
time point 288
time interval 285
time interval 287
CK, -CK
command
row activate
read/write
bank address
activate bank sel
read/write bank sel
row address
activate row addr
read/write col addr

FIGURE 3


time point 381
time point 383
time point 385
time point 387
time point 389
CK, -CK
command
bank address
row address
-CS0
-CS1
row precharge
row activate
read/write
row activate
read/write
precharge bank sel
activate bank sel
read/write bank sel
activate bank sel
read/write bank sel
activate row addr
read/write col addr
activate row addr
read/write col addr
chip 0 select
chip 0 select
chip 0 select
chip 1 select
chip 1 select

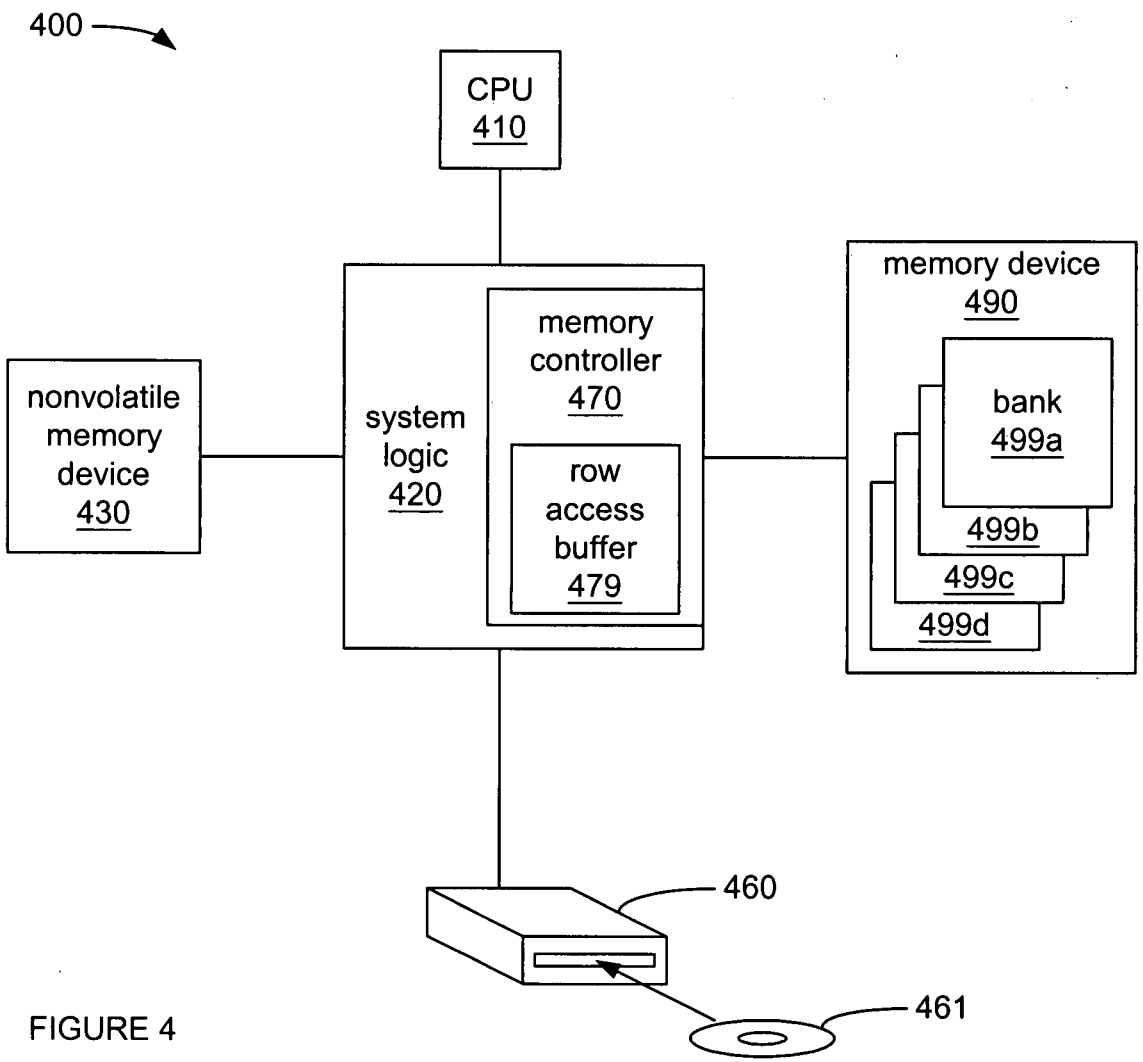
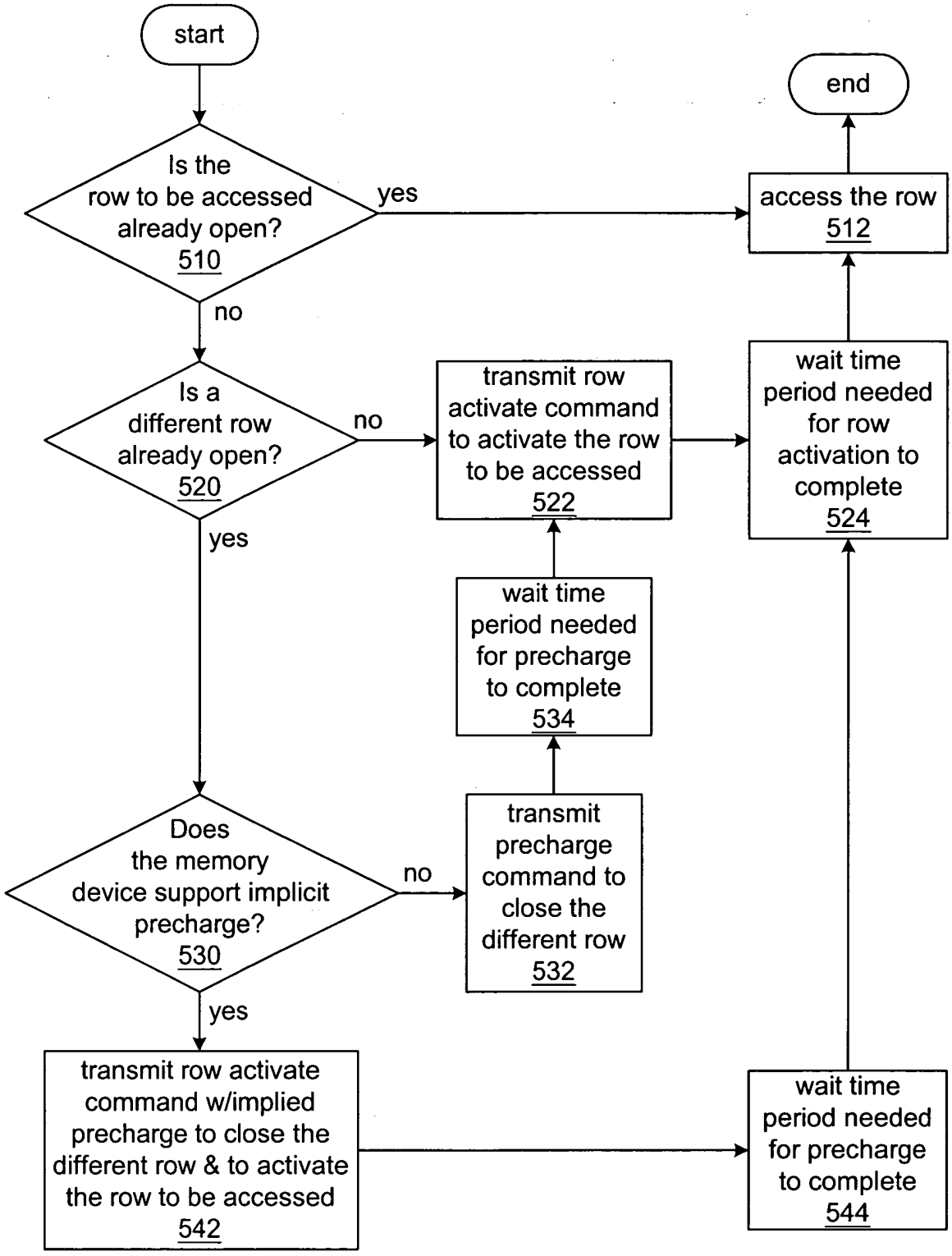

400
CPU
410
memory device
490
memory
controller
470
bank
499a
nonvolatile
memory
device
430
system
logic
420
row
access
buffer
479
499b
499c
499d
460
461

FIGURE 4

FIGURE 5


start
Is the row to be accessed already open? 510
yes
access the row 512
end
no
Is a different row already open? 520
no
transmit row activate command to activate the row to be accessed 522
wait time period needed for row activation to complete 524
yes
wait time period needed for precharge to complete 534
Does the memory device support implicit precharge? 530
no
transmit precharge command to close the different row 532
yes
transmit row activate command w/implied precharge to close the different row & to activate the row to be accessed 542
wait time period needed for precharge to complete 544